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CLIMATE CHANGE LITERACY FOR MITIGATION: A CONCEPTUAL FRAMEWORK LINKING AWARENESS, EDUCATION, AND GOVERNANCE

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ABSTRACT

Climate change literacy remains a critical but underdeveloped foundation for effective mitigation, particularly in developing countries where vulnerability intersects with limited institutional capacity. This article advances a multilevel conceptual framework that extends beyond linear models to position climate change literacy across micro (individual), meso (community and institutional), and macro (societal and governance) levels, linked through dynamic reciprocal feedback processes. Drawing on global and regional evidence, it conceptualizes climate change literacy as a multidimensional construct encompassing scientific understanding, socio-political awareness, ethical engagement, and civic agency. Case examples from Africa, Southeast Asia, and Latin America illustrate how integrating Indigenous knowledge, digital media, and participatory pedagogy can enhance climate understanding and behavioural change. The framework underscores that literacy must extend beyond education to governance, financing, and accountability systems. Institutionalising climate change literacy within national climate and development strategies offers a justice-oriented pathway to strengthen mitigation, resilience, and sustainability in regions most affected by climate change.

KEYWORDS: Climate Change Literacy, Mitigation, Framework, Developing Countries, Governance.

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1. INTRODUCTION

The climate crisis stands as the most formidable existential challenge confronting humanity in the 21st century. From rising sea levels to erratic weather patterns, its manifestations are already reshaping natural and human systems. Studies show that globally four million deaths are linked directly or indirectly to climate change annually (Euronews Green, 2024; Carlson, 2024). Developing countries, particularly in sub-Saharan Africa, South Asia, and parts of Latin America, bear a disproportionate burden of these impacts due to their geographical exposure, economic dependencies on climate-sensitive sectors (like agriculture and fisheries), and limited infrastructural and institutional capacity to respond (IPCC, 2022). These vulnerabilities are exacerbated by historical injustices and global inequalities that leave these nations with fewer resources for adaptation and mitigation.

Yet, in the face of such monumental challenges, climate change literacy remains underdeveloped though a critical, often-overlooked lever for sustainable transformation. Defined as the capacity of individuals and communities to understand, evaluate, and act upon climate-related knowledge, climate change literacy is foundational for empowering societies to make informed decisions, support robust policy frameworks, and engage in mitigation and adaptation activities (UNESCO, 2021; Niepold et al., 2007; Anderson, 2012). Without this knowledge base and civic empowerment, even the most well-intentioned policies or sophisticated technologies risk failure or public resistance.

This article posits that climate change literacy should not be seen as ancillary to technical or financial mitigation mechanisms. Rather, it is central to building resilient societies that can co-create and sustain climate action. Grounded in a global synthesis of academic and grey literature, the paper explores climate change literacy's multidimensional contours and argues for its integration into national climate strategies. The emphasis lies particularly on developing countries, where institutional investments in education and civic engagement are often constrained, yet where the potential gains from an informed populace are profoundly transformative. Unlike dominant climate and environmental literacy models that emphasise awareness or behaviour change in isolation, this article proposes a multilevel conceptual framework that explicitly integrates governance and institutional feedbacks as constitutive elements of climate change literacy itself.

The analysis proceeds through several interrelated sections. After defining and contextualising climate change literacy conceptually, it presents a global assessment of literacy levels and challenges in developing regions. Case studies from Africa, Southeast Asia, and Latin America illustrate how contextualized approaches to climate change literacy yield tangible outcomes. Subsequent sections explore the integration of Indigenous knowledge systems, the role of digital media, and the necessity of institutional and governance frameworks for literacy. A final section outlines a comprehensive implementation strategy, incorporating monitoring and evaluation mechanisms that align with international goals such as the Sustainable Development Goals (SDGs) and the Paris Agreement. Ultimately, the paper argues that advancing climate change literacy is a critical, justice-oriented approach to climate mitigation, and one that must be embraced with urgency and commitment.

1.1. Approach and Conceptual Basis

This study employs a qualitative approach, primarily based on the analysis of secondary data sources. The literature and case examples reviewed were selected purposively guided by their relevance to climate change literacy in developing and climate-vulnerable contexts. Priority was given to peer-reviewed studies, major policy reports, and well-documented grey literature from governmental and non-governmental organizations. We chose literature that explicitly engaged with climate education, literacy, governance, or participatory knowledge systems at individual, community, or institutional levels. These sources provide understanding into national initiatives, public perceptions, and efforts related to climate education and awareness. Case examples from Africa, Southeast Asia, and Latin America were included where they illustrated distinct pathways through which climate change literacy interacts with institutions, governance arrangements, or collective action. The review includes analysis of policy frameworks, case studies, and assessments available publicly, highlighting strategies that have been effective in improving climate literacy.

The analysis involves synthesizing themes and comparing different contexts to identify key patterns, gaps, and best practices. We synthesized themes through iterative reading and comparison of sources, focusing on recurring conceptual dimensions, mechanisms, and relationships across contexts. This comparative approach facilitates insights into how socio-economic and cultural factors influence climate change literacy and suggests adaptable strategies for

South Africa. By relying on previously published work, this approach ensures a comprehensive, evidence-based exploration of the current landscape, aiming to inform future educational and policy interventions to improve climate literacy.

2. CONCEPTUALISING CLIMATE CHANGE LITERACY

Climate change literacy is a multifaceted and evolving concept that integrates scientific understanding, cognitive awareness, social knowledge, and civic capacity. It extends beyond mere comprehension of climate science to encompass the ability to critically evaluate sources of information, recognise socio-economic and political dimensions of the climate crisis, and participate meaningfully in policy discourse and climate action (Anderson, 2012; Raj and Amin, 2024). In this regard, climate change literacy must be situated within broader educational and epistemological paradigms that recognise the interconnection between knowledge, power, and action.

Traditionally, definitions of climate change literacy have been grounded in the natural sciences, emphasizing core competencies in climate system dynamics, greenhouse gas mechanisms, and ecological feedback loops (NOAA, 2009). However, recent scholarship has broadened this view to include emotional engagement, intergenerational perspectives, and ethical responsibility (Skillington, 2019; Stevenson et al., 2014). This more holistic understanding is particularly relevant for developing countries, where climate change intersects with urgent socio-political and developmental concerns such as poverty, inequality, migration, and public health.

A crucial distinction must also be made between climate change literacy and environmental literacy more broadly. While environmental literacy addresses general ecological awareness and sustainability values, climate change literacy is more narrowly concerned with the causes, consequences, and solutions to anthropogenic climate change (McBride et al., 2013; Miléř and Sládek, 2011). It requires not only understanding the science but also comprehending global governance mechanisms (such as the UNFCCC and IPCC), national climate policies, and individual or collective mitigation behaviours (Mehtap, 2023).

From a cognitive standpoint, climate change literacy encompasses declarative knowledge (factual understanding of climate systems), procedural knowledge (skills to interpret climate models and data), and affective knowledge (values, emotions, and motivations towards climate action) (Ofem et al., 2024). In policy contexts, this translates into a literate citizenry that can evaluate climate-related policy proposals, hold governments accountable, and adopt sustainable practices at household, community, and workplace levels.

The concept also entails a sociocultural dimension. In many developing countries, climate knowledge is mediated through local narratives, traditional beliefs, and community-based observation rather than formal education systems (Leichenko & O'Brien, 2008). Therefore, effective climate change literacy programmes must be culturally adaptive and locally contextualised. This includes using vernacular languages, respecting Indigenous knowledge systems, and integrating participatory methodologies that validate community experiences and perspectives.

Finally, climate change literacy is inherently political. It is about empowering citizens not just to understand climate change, but to act as agents of transformation. This means fostering a sense of collective efficacy, environmental citizenship, and policy engagement that is often missing in technocratic climate strategies. Thus, advancing climate change literacy is not merely an educational task, but also a democratic imperative, central to the realisation of equitable and sustainable climate futures.

3. A MULTILEVEL CONCEPTUAL FRAMEWORK FOR CLIMATE CHANGE LITERACY

Despite growing interest in climate change literacy, existing research tends to treat awareness and understanding as primarily individual attributes, measured through education level, knowledge of climate science, or media exposure. While important, such an approach overlooks the fact that climate change literacy is embedded within broader social, institutional, and governance contexts. To address this gap, we propose a multilevel conceptual framework in Figure 1 that situates climate change literacy at the intersection of micro (individual), meso (community and institutional), and macro (societal and governance) structures. This framework advances existing climate and environmental literacy models by moving beyond predominantly linear, individual-level conceptions of knowledge acquisition to explicitly theorise climate change literacy as a dynamic, system-level process. Its central contribution lies in foregrounding reciprocal feedback loops across micro, meso, and macro levels, through which

individual understanding, institutional practice, and governance structures continually shape and reinforce one another. By explicitly linking literacy to governance, policy accountability, and institutional capacity, the model positions climate change literacy not only as an educational outcome but as an enabling mechanism for sustained mitigation action. Although grounded in assumptions from previous literature, the framework will require future quantitative empirical studies to test its validity.

3.1. Micro-level (individual)

At this level, literacy is shaped by demographic and socio-economic characteristics such as age, gender, education, and poverty status, as well as cognitive and affective factors including factual knowledge of climate science, perceived risks, and personal efficacy. Access to media, digital platforms, and formal curricula further mediates the acquisition of climate knowledge. These individual attributes provide the building blocks of climate change literacy, but they do not act in isolation.

3.2. Meso-level (community and institutional)

Individuals are embedded within communities and institutions that act as knowledge intermediaries. Schools, teachers, peer networks, civil society organisations, community leaders, NGOs and local media ecosystems serve as knowledge brokers thus influencing how climate information is interpreted, validated, and shared. Social capital and trust within communities shape collective learning processes, enabling or constraining the adoption of climate knowledge and behaviours. Teacher training, curriculum design, and local advocacy campaigns are also critical at this level.

3.3. Macro-level (societal and governance)

At the macro level, climate change literacy is conditioned by broader policy, institutional, and global structures. National education policies, the integration of climate change literacy into curricula, institutional trust in governments, and international frameworks such as the SDGs and the Paris Agreement form the enabling environment for climate change literacy. Structural vulnerabilities such as inequality, hazard exposure, and colonial legacies also mediate how individuals and communities access, interpret, and act upon climate knowledge by influencing both resource allocation and lived experiences of climate risks.

3.4. Dynamic interactions

The arrows linking these levels highlight the multi-directional nature of climate change literacy formation.

Micro ↔ Meso: Individuals influence and are influenced by their communities, schools, and local organisations.

Meso ↔ Macro: Institutions transmit and mediate national and global policies, while also feeding community concerns upward into governance processes.

Micro ↔ Macro (dotted line): Individual experiences and activism can shape national debates, while top-down policies and conditions can affect some individual-level factors.

3.5. Implications

This framework advances the field by positioning climate change literacy as a systemic, multilevel construct. It enables researchers to operationalise climate change literacy not only as an individual outcome but as a phenomenon co-produced by institutions and governance systems. For policymakers, the framework highlights leverage points at each level, showing how interventions in education, community engagement, and governance can work synergistically to strengthen climate change literacy as a driver of mitigation. Ultimately, strengthening climate change literacy requires interventions that are coordinated across levels to build informed, resilient, and empowered societies.

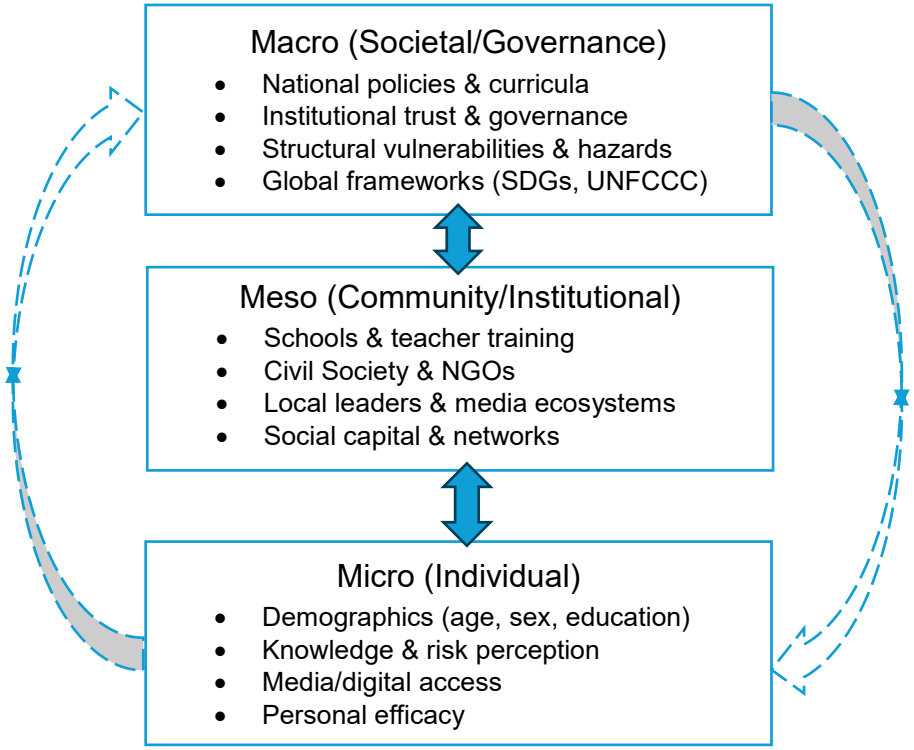


Figure 1. A Multilevel Conceptual Framework for Climate Change Literacy.
Source: Authors' own illustration (2025), developed for this study.

4. ASSESSING CLIMATE CHANGE LITERACY IN DEVELOPING REGIONS

Despite growing international recognition of the importance of climate change literacy, empirical assessments reveal a troubling disparity in literacy levels between high-income and developing countries. This gap is attributable to several structural and systemic factors, including limited access to quality education, language barriers, inadequate teacher training, poor curriculum integration, and low public investment in environmental awareness (Azeiteiro et al, 2018).

The educational system in developing countries often lacks structured content on climate change. A UNESCO (2019) global monitoring report revealed that only 30% of curricula in sub-Saharan Africa included climate change topics, and these were often limited to science subjects with minimal emphasis on socio-political dimensions or action-oriented skills. Moreover, textbooks and teacher training materials are frequently outdated or misaligned with the latest scientific findings from sources such as the IPCC.

Empirical case studies further illuminate these challenges. In Bangladesh, while national education policies acknowledge climate vulnerability, actual classroom instruction on the topic remains inconsistent and under-resourced (Asante, 2022). Similarly, in Uganda, climate change literacy is often sidelined due to lack of educator capacity and lack of explicit pedagogical support (Mwangu et al., 2017).

Nonetheless, there are promising initiatives. In South Africa, the Department of Basic Education has initiated reforms to mainstream climate change content into the national curriculum, supported by training programs and partnerships with local NGOs (Lotz-Sisitka et al., 2021). In Indonesia, participatory environmental education campaigns have improved youth awareness and engagement in climate resilience projects (Agbedahin , 2019; UNESCO, 2021).

The assessment of climate change literacy must also consider informal education channels. Radio programs, community theatre, mobile apps, and social media are increasingly used to disseminate climate information in accessible ways. In Kenya, for example, the "Shamba Shape-Up" TV program blends agricultural advice with climate adaptation strategies, reaching millions of rural viewers (Vyas et al., 2024).

Despite these innovations, many developing regions still lack a national framework for monitoring climate change literacy. As such, data collection remains fragmented, impeding

comparative analysis and evidence-based policymaking. To address this, tools such as UNESCO's Education for Sustainable Development indicators and the Global Education Monitoring Report provide valuable guidance but require national commitment to implementation (UNESCO, 2020; 2023) .

In summary, while the foundations for climate change literacy exist in many developing countries, systemic barriers limit its widespread uptake and integration. Addressing these gaps demands not only pedagogical reform but also political will, resource mobilization, and inclusive approaches that reflect local realities and capacities.

5. CASE STUDIES: REGIONAL INNOVATIONS IN CLIMATE CHANGE LITERACY

In the pursuit of enhancing climate change literacy across developing countries, regional innovations provide critical insights into effective strategies that bridge scientific knowledge and community engagement. These case studies reveal the complex interplay of cultural, institutional, and socio-economic factors shaping the uptake and efficacy of climate change literacy initiatives. By exploring efforts in Africa, Southeast Asia, and Latin America, this section highlights how localized, context-sensitive approaches serve not only to inform but also to empower diverse populations to participate actively in climate mitigation.

5.1 Africa: South Africa's Curriculum Integration and Community Engagement

South Africa offers a compelling example of institutionalizing climate change literacy through formal education reform. Recognizing the intersection between climate vulnerability and socio-economic inequality, the Department of Basic Education has progressively embedded climate change content into the national school curriculum since the mid-2010s (Lotz-Sisitka et al., 2021). This initiative transcends traditional science teaching by incorporating interdisciplinary modules that emphasize socio-political dimensions of climate change, such as environmental justice and sustainable development. Teacher training programs, often in partnership with NGOs and universities, focus on equipping educators with pedagogical tools to engage students critically with climate data and policy debates.

Importantly, the South African approach integrates community-based learning, wherein schools collaborate with local organisations to facilitate experiential activities such as water conservation projects, waste management drives, and renewable energy demonstrations. Such initiatives enhance procedural knowledge and foster civic agency among youth, as evidenced by increased participation in local environmental governance forums (Boon, 2024; du Plessis, 2008). However, challenges persist, particularly in rural and under-resourced areas where infrastructural deficits and limited digital access constrain program reach. These disparities highlight the necessity for complementary informal education strategies. For instance, only 30% of schools in South Africa have reliable internet connectivity for teaching and learning purposes, while in Uganda's northern districts, intermittent electricity and poor mobile-network coverage have hindered the rollout of UNESCO's digital Education for Sustainable Development (ESD) modules, forcing educators to adapt through community workshops and storytelling sessions (Mnynadu et al., 2023; Mwangu et al, 2017; UNESCO, 2020).

One notable informal innovation is the proliferation of community radio programs that disseminate climate information. For example, research on a youth-led climate change and sustainable living radio campaign "Earth our home" showed that although behavioural change occurred among a subset of respondents, the majority demonstrated an enhanced sense of personal agency (Petit-Perrot, 2022). This synergy of formal and informal education exemplifies a holistic literacy ecosystem that acknowledges the diverse knowledge landscapes within South Africa.

5.2 Southeast Asia: Participatory Climate change literacy in Indonesia

Teacher training initiatives, often in collaboration with NGOs, have played a key role. A more detailed discussion on educator capacity-building can be found in Section 9.

In Central Kalimantan, for instance, community workshops led by environmental NGOs have facilitated dialogues between scientists, local leaders, and youth about sustainable peatland management—critical for carbon sequestration and biodiversity conservation. These workshops employ storytelling and hands-on activities, such as peatland restoration and fire prevention drills, to translate abstract climate concepts into tangible, locally relevant actions (Harrison et al., 2020). Youth participants in these programs report heightened awareness of the socio-ecological interdependencies that define their landscape and express greater willingness to engage in mitigation behaviours,

including reducing slash-and-burn farming practices.

Indonesia's participatory climate education includes community workshops and digital platforms for outreach. For broader analysis of digital tools in climate literacy, refer to Section 7.

5.3 Latin America: Indigenous Knowledge and Climate Resilience

Ecuador exemplifies how Indigenous knowledge systems can enrich climate change literacy efforts. Rather than duplicating content, this section briefly highlights Ecuador's integration of Indigenous epistemologies. For a full analysis of Indigenous knowledge systems and their role in climate literacy, see Section 6.

In the Amazonian provinces, climate change literacy initiatives have been co-designed with Indigenous organisations to respect and amplify traditional worldviews while integrating contemporary climate science (López et al., 2017). Educational programs utilise bilingual materials that merge scientific terminology with Indigenous languages like Kichwa, ensuring accessibility and cultural resonance (Ciavattone, 2023). This integrative approach empowers Indigenous youth as custodians of both ancestral knowledge and modern climate narratives, fostering hybrid literacies that facilitate community-led adaptation projects, such as agroforestry and watershed protection.

Moreover, local radio, participatory theatre and eco/climate emotions have been employed as effective tools for climate communication, engaging broader audiences beyond formal classrooms (Guevara, 2024). The "Voices of the Forest" project, for example, engages interspecies communication to amplify ecological awareness while "The Climate Monologues" combines storytelling, music, and dramatisation to raise awareness and inspire people to take action on climate change in their own lives, simultaneously fostering social cohesion and environmental stewardship (Abreu, n.d.; Voices of the Forest, n.d.). These culturally embedded methodologies illustrate how climate change literacy can be democratized and decolonized, challenging dominant paradigms that privilege Western scientific knowledge.

These regional case studies underscore that advancing climate change literacy in developing countries demands tailored approaches that recognize historical, cultural, and institutional specificities. Formal education reforms, participatory community engagement, and innovative use of media together constitute a mosaic of strategies that enhance understanding and catalyse action. However, sustaining these gains requires systemic support, cross-sector collaboration, and ongoing adaptation to emerging climate realities.

6. INTEGRATING INDIGENOUS KNOWLEDGE SYSTEMS IN CLIMATE CHANGE LITERACY

The integration of Indigenous knowledge systems (IKS) into climate change literacy frameworks represents both a profound opportunity and a complex challenge, particularly within developing countries where Indigenous peoples often live in climate-vulnerable ecosystems. Indigenous knowledge defined broadly as the cumulative body of knowledge, practices, and beliefs developed by local communities over generations, embodies deeply contextualised understandings of natural processes, biodiversity, and resource management (Berkes, 2009). This knowledge is inherently adaptive, relational, and transmitted through oral traditions, rituals, and lived experiences, offering nuanced insights into local climate variability and resilience strategies (Whyte, 2017, 2018).

Historically marginalised by dominant Western scientific paradigms, Indigenous knowledge systems have often been excluded from formal climate change literacy and policy discourse, thereby perpetuating epistemic injustice and undermining effective adaptation (Byskov and Hyams, 2022; Escobar, 1995). However, recent scholarship and international frameworks have increasingly recognized the indispensability of Indigenous epistemologies in climate governance (Chanza and De Wit, 2016). The Intergovernmental Panel on Climate Change (IPCC) reports explicitly call for the inclusion of Indigenous and local knowledge in climate assessments and adaptation planning (IPCC, 2019). Similarly, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) affirms Indigenous peoples' right to maintain and control their cultural heritage and traditional knowledge.

Incorporating Indigenous knowledge into climate change literacy enhances the cognitive and affective dimensions of learning by fostering respect for diverse worldviews and encouraging pluralistic approaches to environmental stewardship. This integration requires rethinking conventional educational structures that often prioritize standardized curricula and didactic teaching methods. Instead, it calls for participatory, dialogic pedagogy that values Indigenous languages, storytelling, and experiential learning (Ogegbo and Ramnarain, 2024).

Empirical studies illustrate the efficacy of such approaches. In the Pacific Islands, for example, climate change literacy programs have incorporated traditional navigation and weather forecasting techniques alongside meteorological science, strengthening community resilience and intergenerational knowledge transmission (Chamber et al., 2019). Similarly, in the Amazon Basin, Indigenous-led mapping projects document ecological changes and inform climate adaptation strategies, reinforcing local agency and scientific collaboration (Lopez et al., 2017).

Challenges to integration persist, including institutional resistance, language barriers, and the risk of knowledge appropriation without adequate consent or benefit-sharing. Ethical engagement requires co-creation processes where Indigenous communities are partners rather than mere subjects of climate change literacy initiatives (Shabalala, 2025). Furthermore, policy frameworks must safeguard Indigenous intellectual property rights and promote capacity building within Indigenous educational institutions.

For developing countries grappling with climate change, embracing Indigenous knowledge systems within climate change literacy initiatives offers pathways toward justice-oriented and contextually grounded mitigation and adaptation. This pluralistic epistemology not only enriches scientific understanding but also empowers Indigenous communities as key actors in climate governance, thereby advancing sustainability and resilience on multiple fronts.

7. THE ROLE OF DIGITAL MEDIA IN ENHANCING CLIMATE CHANGE LITERACY

In the contemporary landscape of climate communication, digital media platforms have emerged as pivotal tools for enhancing climate change literacy, especially in developing countries where traditional educational infrastructures may be limited or unevenly distributed. The proliferation of mobile technology, internet connectivity, and social media networks has revolutionized information dissemination and civic engagement, creating new avenues for knowledge exchange and public participation in climate action (Olaniyi et al., 2025). Digital media thus offers both unprecedented opportunities and unique challenges for fostering climate change literacy as a driver of mitigation efforts.

One of the foremost advantages of digital media lies in its capacity to overcome geographic and socio-economic barriers. In rural and remote regions, where access to formal education or extension services is often scarce, mobile phones and radio broadcasts have become indispensable conduits for climate-related information. For instance, in Kenya, the integration of SMS-based weather alerts with agricultural advisory services has empowered smallholder farmers to make climate-smart decisions, reducing vulnerability to erratic rainfall patterns and drought (Ngigi and Muange, 2022). Similarly, digital storytelling through community radio can be effective in raising awareness about climate change and enhancing community dialogue (Mbugua et al., 2024).

Social media platforms such as Facebook, Twitter, and WhatsApp also play a transformative role in democratizing climate knowledge. These networks facilitate rapid dissemination of scientific findings, policy updates, and grassroots innovations, allowing users to share locally relevant content and mobilize collective action. In the Philippines, youth-led climate advocacy campaigns leveraging social media have not only increased awareness but also influenced local government policies on disaster risk reduction (Fernandez & Shaw, 2013). Such digital activism exemplifies how climate change literacy extends beyond passive reception of information to encompass active participation and empowerment.

However, the digital terrain is fraught with challenges that complicate the use of these platforms for climate change literacy. Issues of digital inequality seen through disparities in access, digital skills, and language inclusion threaten to exacerbate existing educational and informational divides (Heeks, 2022). In many developing countries, women, marginalized ethnic groups, and impoverished communities face structural barriers to digital participation, limiting their exposure to climate knowledge and agency in mitigation efforts (Antonio & Tuffley, 2014). Moreover, the prevalence of misinformation and climate denialism on digital platforms undermines public understanding and trust, necessitating robust fact-checking and media literacy components within climate change literacy programs (Tomassi et al., 2025; Treen et al., 2020).

To address these complexities, integrated digital strategies that combine formal and informal educational approaches are essential. Mobile learning applications tailored to local contexts, languages, and cultural norms have shown promise in enhancing climate change literacy among diverse populations. For example, mobile climate information services in Bangladesh have deployed interactive modules on climate change science,

adaptation techniques, and policy frameworks, reaching thousands of rural users with limited formal education (Shah et al., 2022). Partnerships between governments, NGOs, and tech companies are also critical to expanding digital infrastructure, improving user training, and curating reliable content. The emergence of digital citizen science initiatives represents a novel frontier for climate change literacy. Platforms enabling community members to collect and share environmental data (e.g. air quality, rainfall, biodiversity) foster experiential learning and strengthen local ownership of climate monitoring and mitigation (Albagli & Iwama 2022; Hsu et al. 2017).

Digital media is an indispensable asset for expanding climate change literacy in developing countries, offering scalable and adaptable tools that complement traditional education systems. However, realizing its full potential requires concerted efforts to bridge digital divides, combat misinformation, and align digital content with cultural and linguistic diversity. Through these means, digital media can empower individuals and communities not only to understand climate change but to act decisively in mitigating its impacts and shaping resilient futures.

8. INSTITUTIONAL AND GOVERNANCE FRAMEWORKS FOR CLIMATE CHANGE LITERACY

The advancement of climate change literacy cannot be disentangled from the institutional and governance contexts within which educational policies and climate actions are formulated and implemented. Robust institutional frameworks and effective governance mechanisms are essential to mainstream climate change literacy into national development agendas, mobilize resources, and ensure coherent coordination among multiple stakeholders. This is especially critical in developing countries, where institutional capacities vary widely, and governance challenges such as policy fragmentation, limited enforcement, and resource constraints often hinder sustainable climate change literacy efforts (Cao et al., 2024).

Institutionalizing climate change literacy requires embedding it within formal education systems, civil society initiatives, and governmental planning processes. Ministries of education, environment, and science and technology must collaborate to develop comprehensive curricula that reflect current climate science, socio-political realities, and mitigation imperatives. For instance, South Africa's Department of Basic Education has taken notable steps by integrating climate change themes into Life Skills and Natural Sciences curricula, supported by teacher training programs and partnerships with environmental NGOs (Lotz-Sisitka et al., 2021). Similarly, in Malawi, UNESCO supported a multi-ministry initiative to 'green the curriculum' through coordinated curriculum review, integration of climate change across disciplinary subjects, and teacher education reform (UNESCO, 2025a). Such multi-sectoral coordination exemplifies how governance structures can create enabling environments for systemic climate change literacy enhancement.

Beyond curriculum reform, institutional frameworks must also support capacity building among educators, community leaders, and policymakers. Professional development programs tailored to climate change education equip teachers with the scientific knowledge and pedagogical skills necessary to engage students critically and creatively (Casado-Asensio et al., 2022). Moreover, local governments play a vital role in facilitating community-based climate change literacy initiatives, often acting as intermediaries between national policies and grassroots implementation. In Indonesia, decentralization has empowered regional authorities to design context-specific climate change literacy campaigns, resulting in increased local engagement and adaptive capacity (Tang, 2024).

Governance mechanisms for climate change literacy also entail fostering participatory platforms that amplify diverse voices, including marginalized groups and Indigenous communities. Democratic governance approaches promote transparency, accountability, and inclusivity, ensuring that climate change literacy initiatives reflect local priorities and knowledge systems (O'Brien et al., 2018). The establishment of climate councils, citizen assemblies, and youth forums has been instrumental in several developing countries for bridging gaps between policymakers and citizens, thereby enhancing trust and policy responsiveness (Blair, 2016).

Financial governance is another critical dimension. Adequate and sustained funding streams are necessary to support curriculum development, resource production, outreach campaigns, and monitoring systems. International climate finance mechanisms such as the Green Climate Fund and Global Environment Facility increasingly recognize the importance of education and awareness raising as components of climate action plans, providing avenues for resource mobilization in developing countries (Dagnet et al., 2017). However, ensuring that funds are equitably allocated and effectively

utilized requires transparent budgeting processes and anti-corruption safeguards.

Additionally, intergovernmental coordination and alignment with global climate governance frameworks enhance the legitimacy and coherence of national climate change literacy strategies. The integration of climate change literacy goals within the Sustainable Development Goals (SDGs), particularly SDG 4 on quality education and SDG 13 on climate action, offers a strategic policy nexus that can galvanize multi-sectoral commitment and reporting (UNESCO, 2019). Countries that successfully harmonize domestic policies with international obligations demonstrate higher rates of literacy program implementation and innovation (Nilsson et al., 2018).

Nonetheless, governance challenges persist, especially in fragile states where political instability, weak institutions, and competing development priorities undermine the establishment of effective climate change literacy programs (Kelman et al., 2017). Addressing these challenges necessitates international collaboration, technical assistance, and adaptive governance models that are flexible to local contexts and crises.

Institutional and governance frameworks constitute the backbone of climate change literacy advancement in developing countries. Effective integration of climate change literacy into formal and informal settings, capacity building, participatory governance, and sound financial management collectively enable the transformative potential of climate change literacy to be realized. For these frameworks to function optimally, sustained political will, cross-sectoral collaboration, and alignment with global climate agendas are indispensable.

9. IMPLEMENTATION STRATEGIES AND BEST PRACTICES

This section synthesizes best practices, drawing on case studies from earlier sections. Readers are encouraged to refer to Section 5 for detailed regional implementations. Effective implementation of climate change literacy programs in developing countries requires a nuanced and multi-dimensional strategy that bridges theoretical frameworks with practical realities on the ground. Recognizing the complex socio-economic, cultural, and institutional landscapes characteristic of these regions is vital to designing programs that are not only informative but transformative, engendering lasting behavioural change and collective action for climate mitigation.

A foundational principle of successful implementation lies in the contextualization of climate change literacy content. Climate change literacy cannot adopt a one-size-fits-all approach; it must be tailored to local realities, vernacular languages, and cultural epistemologies. Empirical studies from Latin America demonstrate that programs embedding Indigenous knowledge systems alongside scientific explanations yield higher engagement and empowerment among rural communities (Jiménez-Aceituno et al., 2025). Similarly, in the Sahel region of Africa, integrating pastoralists' traditional climate forecasting with formal meteorological data has enhanced community resilience and knowledge legitimacy (Ziervogel and Opere, 2010). Such culturally sensitive curricula respect community agency and foster a sense of ownership critical to sustained engagement.

Another key strategy involves multi-sectoral partnerships that mobilize the strengths of government agencies, non-governmental organizations, academic institutions, and the private sector. These collaborations facilitate resource sharing, capacity building, and innovation diffusion. For instance, in the Philippines, the partnership between the Department of Education, local NGOs, and media organizations led to the nationwide rollout of climate change literacy modules integrated with disaster risk reduction education, substantially improving school-level climate awareness and preparedness (Alcala et al., 2019). Partnerships also enable the leveraging of technology, as seen in India's collaboration between government bodies and tech startups to develop digital tools that reach remote populations (Darapaneni et al., 2022).

Implementation strategies must also prioritize the professional development of educators and facilitators. Teachers, extension officers, and community leaders are frontline agents who translate climate change literacy policies into lived experiences. Continuous training programs that provide up-to-date scientific knowledge, pedagogical techniques, and cultural competence have been linked to improved learning outcomes (Darling-Hammond et al, 2017).

In addition to formal education settings, informal and non-formal learning environments serve as critical platforms for climate change literacy. Community workshops, peer education, storytelling, and arts-based methods harness local creativity and social networks to disseminate knowledge and inspire action. The use of theatre and participatory video in Mozambique, for instance, has empowered youth to communicate climate change impacts and adaptation strategies to broader audiences, fostering intergenerational dialogue and social cohesion

(Mancilla et al., 2025).

Crucially, implementation must be supported by comprehensive monitoring and evaluation (M&E) frameworks that track progress, assess effectiveness, and inform adaptive management. Robust M&E mechanisms include baseline assessments, participatory feedback loops, and longitudinal studies to capture knowledge retention, behavioral changes, and community impacts (Patton, 2011). Moreover, integrating M&E systems with national reporting frameworks ensures alignment with international climate commitments and facilitates resource allocation.

Financing implementation remains a central challenge but also an opportunity for innovation. Blended financing approaches that combine public funding, donor grants, and private sector investment have proven effective in scaling climate change literacy initiatives. For example, the Green Climate Fund's support for climate change literacy in South Sudan and Togo has been augmented by corporate social responsibility programs from local enterprises, expanding outreach and material development (Chirambo, 2021; GCF, 2020). Social enterprises and community-based organizations increasingly use revenue-generating activities such as eco-tourism and sustainable agriculture training to fund ongoing education programs, enhancing financial sustainability and community buy-in; or example, Honey Care Africa's beekeeping enterprise supports village-level training and extension services financed from honey revenues (Wang et al., 2017).

Lastly, scaling successful models requires policy advocacy and integration within broader national climate and development strategies. Embedding climate change literacy goals into education sector plans, national climate action plans (NDCs), and SDG frameworks ensures political commitment and institutional continuity. Countries like Costa Rica have institutionalized climate change literacy as a cross-cutting theme in their national sustainability agenda, embedding it in executive decrees, national strategies, and formal curricula (UNESCO, 2021). Such top-down support complements grassroots innovation, creating synergistic dynamics that accelerate climate change literacy uptake.

Therefore, implementing climate change literacy in developing countries demands a holistic approach that is culturally grounded, multi-sectoral, capacity-building focused, and rigorously monitored. By adopting these best practices, nations can transform climate change literacy from a peripheral educational endeavour into a strategic pillar of climate mitigation, resilience, and sustainable development.

10. MONITORING AND EVALUATION STRATEGIES FOR CLIMATE CHANGE LITERACY PROGRAMS

Monitoring and evaluation (M&E) are indispensable components of effective and sustainable climate change literacy programs, especially in developing countries where resource constraints and socio-political complexities necessitate rigorous oversight and adaptive management. Robust M&E systems enable stakeholders to assess the reach, quality, and impact of literacy interventions, identify challenges and opportunities, and refine strategies to maximize educational and behavioural outcomes.

These systems must assess not only outputs (e.g., number of trained teachers, distributed materials) but also outcomes and impacts, such as changes in knowledge, attitudes, behaviours, and community resilience. For example, the UNESCO Education for Sustainable Development framework advocates for indicators that capture not only cognitive gains but also affective and action-oriented outcomes, recognizing that climate change literacy is as much about transforming values and behaviours as about imparting information (UNESCO, 2025b).

Baseline assessments constitute the initial step in M&E, providing a snapshot of existing climate change literacy levels within target populations. Such assessments employ a variety of quantitative and qualitative tools, including standardized surveys, focus group discussions, and participatory mapping. For instance, in Bangladesh, baseline surveys measuring community understanding of climate change and its impacts concluded that context-specific school-based intervention could be explored to increase peoples' knowledge about climate change (Kabir et al., 2016). Establishing baselines also facilitates longitudinal tracking, allowing programs to document progress over time and attribute observed changes to specific interventions.

Data collection methodologies should be diverse and inclusive, combining standardized instruments with participatory approaches to capture nuanced insights and foster stakeholder ownership. For example, pre- and post-intervention surveys can measure knowledge gains, while focus groups and ethnographic methods can explore shifts in community perceptions and practices. Participatory evaluation methods, such as community scorecards, participatory rural appraisal (PRA), and storytelling, empower learners and local actors to contribute meaningfully to the evaluation process, enhancing the relevance and legitimacy of findings (Patton, 2011). In sub-Saharan Africa, such methods have

proven effective in integrating Indigenous knowledge and local perspectives into M&E systems, thereby enriching data quality and promoting culturally responsive programming (Ziervogel & Opere, 2010).

Indicators for monitoring climate change literacy programs must be multidimensional, reflecting the complex interplay between knowledge, attitudes, and behaviours. Indicators should be both quantitative and qualitative, capturing cognitive, affective, and behavioural dimensions of literacy. Cognitive indicators assess factual understanding of climate science, mechanisms, and policy frameworks, often through pre- and post-tests or knowledge quizzes. Affective indicators measure changes in perceptions, concern, and motivation regarding climate issues, captured via attitudinal surveys or psychometric scales. Behavioural indicators evaluate tangible actions undertaken by individuals and communities, such as adoption of sustainable practices, participation in mitigation initiatives, or advocacy activities (Ofem et al., 2024). At a national level, education management information systems (EMIS) can be adapted to include climate change literacy metrics. International frameworks such as the SDGs (especially Target 13.3) and the UNESCO ESD framework offer guidance for aligning indicators with global benchmarks.

To assess broader societal impacts, evaluations should also consider community-level and institutional outcomes. These may include enhanced social cohesion, strengthened local governance for climate action, or increased incorporation of climate change literacy into formal education policies and programs. For example, the Philippine Climate Change Adaptation project's M&E framework included indicators tracking the establishment of climate clubs in schools and community-led environmental projects, linking literacy efforts to observable mitigation and resilience benefits (Alcala et al., 2019).

Data analysis must be rigorous and transparent, employing mixed-methods approaches that triangulate findings and contextualize quantitative trends with qualitative narratives. This enhances the credibility of results and supports evidence-based decision-making. Digital tools and platforms increasingly facilitate real-time data collection, visualization, and dissemination, improving responsiveness and stakeholder engagement. Kenya's agro-weather tool enables rapid feedback from dispersed rural farmers, contributing to adaptive program management (Stankovic et al., 2022).

Reporting mechanisms should be designed to communicate findings effectively to diverse audiences, including policymakers, funders, educators, and community members. Clear, accessible reporting builds accountability and reinforces the importance of climate change literacy as a strategic priority. Integrating M&E data into national climate change reporting frameworks, such as those required under the Paris Agreement's Enhanced Transparency Framework, ensures alignment with international commitments and enhances resource mobilization prospects (Dagnet et al., 2017).

However, implementing comprehensive M&E systems in developing countries is often constrained by limited financial, technical, and human resources. Addressing these constraints calls for capacity-building initiatives that train local evaluators and educators in M&E methodologies, data management, and analysis. International development agencies and climate finance institutions increasingly support such capacity development, recognising that sustainable climate change literacy hinges on local ownership of monitoring processes (Casado-Asensio et al., 2022; Fahey et al, 2016).

Adaptive management is a critical principle underpinning effective M&E, emphasizing continuous learning and flexibility. Climate change literacy programs must be responsive to emerging data, stakeholder feedback, and shifting environmental and socio-political contexts. For example, in Indonesia, iterative evaluation cycles have enabled educators to adjust pedagogical content and delivery methods in response to learner comprehension challenges and local climate events (Tang, 2024).

Scaling up successful initiatives requires strategic investment, political commitment, and adaptive learning. Pilot projects should be documented rigorously and evaluated independently to identify best practices and areas for improvement. Funding mechanisms, such as climate finance from the Green Climate Fund, can support the expansion of proven models. Cross-national learning is also vital. Regional organisations such as the African Union, Association of Southeast Asian Nations (ASEAN) and MERCOSUR (Southern Common Market) can facilitate knowledge exchange and harmonisation of approaches, fostering a collective response to shared climate challenges.

Monitoring and evaluation are vital to ensuring that climate change literacy programs in developing countries achieve their intended educational, behavioural, and societal outcomes. By employing

participatory, multidimensional, and adaptive M&E strategies, programs can demonstrate impact, enhance effectiveness, assist in scaling up initiatives and contribute meaningfully to the global imperative of climate change mitigation and sustainable development.

11. CONCLUSION AND POLICY RECOMMENDATIONS

Climate change literacy is not a luxury, rather it is a necessity. This synthesis shows that climate change literacy is not merely an educational concept but a transformative imperative central to effective climate change mitigation in developing countries. As this article has demonstrated, the multidimensional nature of climate change literacy encompassing scientific understanding, socio-political awareness, ethical engagement, and civic empowerment positions it as a foundational pillar upon which sustainable climate action can be built. In contexts where vulnerabilities to climate impacts are acute and institutional capacities often limited, investing in climate change literacy offers a pragmatic and justice-oriented pathway to amplify mitigation efforts and enhance resilience.

The evidence reviewed underscores that advancing climate change literacy requires comprehensive, contextually tailored strategies that integrate formal and informal education systems, leverage local knowledge, and foster multi-sectoral collaboration. The interplay between culturally sensitive curricula, empowered educators, participatory learning methodologies, and innovative technological platforms creates enabling environments for knowledge uptake and behavioural transformation. Moreover, embedding climate change literacy within broader national climate policies and development frameworks ensures political commitment and resource allocation critical for scalability and sustainability.

Monitoring and evaluation frameworks further reinforce the efficacy of climate change literacy programs by providing data-driven insights that guide adaptive management and accountability. Participatory and multidimensional M&E approaches enhance the relevance and legitimacy of findings while building local capacities for sustained program ownership. These elements collectively contribute to a virtuous cycle of learning, improvement, and impact.

Based on this analysis, several policy recommendations emerge for stakeholders committed to embedding climate change literacy within the climate mitigation agenda of developing countries:

First, policymakers should institutionalize climate change literacy as a core component of national education policies and climate action plans. This requires the development and continuous revision of curricula that balance scientific rigor with socio-cultural relevance, ensuring accessibility across diverse linguistic and demographic groups. Legislative frameworks mandating climate change literacy can provide the necessary impetus and stability for sustained implementation.

Second, substantial investment must be directed towards teacher training and capacity-building programs that equip educators with the scientific knowledge, pedagogical skills, and cultural competencies essential for effective climate change literacy delivery. Such investments will yield multiplier effects as teachers become catalysts for community engagement and behaviour change.

Third, multi-sectoral partnerships between governments, civil society, academia, and the private sector should be actively fostered to mobilize resources, share expertise, and innovate educational technologies and outreach methods. These partnerships enable the scaling of successful pilot initiatives and the integration of climate change literacy with related development priorities such as health, agriculture, and disaster risk reduction.

Fourth, innovative approaches to informal and non-formal education—including community workshops, media campaigns, arts-based methods, and digital platforms—should be leveraged to reach marginalized and vulnerable populations who often fall outside formal education systems. Recognizing diverse learning styles and communication channels enhances inclusivity and broadens societal engagement with climate issues.

Within national climate governance frameworks to track progress, measure impacts, and inform iterative improvements. Emphasis should be placed on participatory evaluation methods that empower communities and foster accountability.

Finally, sustainable financing mechanisms are essential to support the long-term viability of climate change literacy programs. Governments and international donors should explore blended financing models that incorporate public funds, climate finance instruments, and private sector contributions, ensuring that investments in education translate into durable mitigation outcomes.

In conclusion, climate change literacy represents a powerful but underleveraged lever for climate mitigation in developing countries. By embedding

comprehensive, culturally attuned, and participatory literacy initiatives within broader policy frameworks, developing nations can cultivate informed, motivated, and empowered citizenries capable of driving meaningful climate action. This integrative approach is not only a pragmatic response to global environmental imperatives but also a pathway to greater social justice and sustainable development.

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